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ABSTRACT

Responses to a questionnaire by 305 of 600 former high school students in the Science Honors Program (SHP) at Columbia University from 1959 to 1961 were analyzed to identify talents and interests during high school that were associated with scientific interests in college, graduate school, and subsequent careers. The program, sponsored by the National Science Foundation, involved selection procedures such as testing with the Pre-Engineering Ability Test and courses taught by university faculty. Some of the findings for high school: (1) a mean IQ of 140; (2) college completion by most parents; (3) professional employment of 73 percent of fathers; and (4) first choice of mathematics, science, or engineering by 94 percent of students. Findings for college: (1) attendance at prestigious institutions such as Harvard, (2) adherence by most students to anticipated major, (3) a significant relationship between major choice and a laboratory in the home during high school, and (4) a relationship between sex and major choice. Some of the findings for graduate school: (1) 80 percent of students continued in the same major, (2) physical science majors scored higher in mathematics than biological science and nonscience majors, and (3) continued interest in science related to the home laboratory. Findings associated with careers were based on scientific publications and indicated that approximately one-third of the sample published at least one scholarly work within 10 years of college graduation. (Tables of statistical data are included.) (MC)

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Career Development of High School Students Talented in Science

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Introduction

There is a long history of research into factors associated with extraordinary talent in a number of professional fields. While much of this research has been retrospective, finding talented practitioners and then determining their backgrounds, there have been some longitudinal studies. The major concern in this paper will be with scientists and with factors associated with productivity in science.

Roe (1965) has done comprehensive work on the background and the psychological dymanics of scientists. She focused on groups of established professionals in a number of areas and then determined psychological and background factors in these scientists. As a part of his studies on the Genetic Studies of Genius, Terman et. al. have studied scientists and non-scientists in their group of bright California students. Similarly, Brandwein (1955) followed a group of talented high school students over a number of years and reported their progress. More recently, Cooley (1963) has reported the results of a overlapping longitudinal study of interest and performance in science from junior high school through the early years of college. Similarly, James (1972) has reported on the traits associated with persistence in science at the college level.

The major purpose of this study was to identify those talents and interests in the high school background of students talented in science that were associated with the pursuit of scientific interests in college, graduate school, and subsequent careers.

Methods

The students who comprised the sample for the study consisted of students who were enrolled in the Science Honors Program at Columbia University in the years 1959 - 1961. The Science Honors Program (SHP) is sponsored by the National Science Foundation for high school students of exceptional talent in science or mathematics. The Program consists of a series of college level classes taught primarily by Columbia faculty. These classes are designed to provide enrichment for these talented students whose high school science experiences are rather more limited.

Selection for SHP is a two stage process. High schools in the New York Metropolitan area are requested to nominate one or two applicants to the Program who are preceived as having both an interest in and a talent for science. The high school will then provide transcript data and recommendations on the student. SHP then administers a standardized test of academic ability to these students. In the years 1959 - 1961 the tests we used were the Pre-Engineering Ability Test and the SCAT math and science subtests. On the basis of this information as well as some interviews, applicants are selected for the Program.

The Program is highly selective. Even allowing for the fact that high schools will nominate only one or two of their most talented students the subsequent selection ratio is also quite low. In most years only about one in four of the nominated applicants are accepted for the Program.

The population consisted of each of the students who had enrolled in the SHP in the years 1959 - 1961. This group comprised approximately 600 students. The initial mailing was to the

address listed on the SHP application which was usually the parent's house. A cover letter was included with instructions to the parents to forward the questionnaires to their children. This initial mailing produced approximately 200 responses. A second mailing was sent by certified mail with instructions to forward. This produced approximately 100 additional responses with 200 questionnaires returned by the Post Office as non-deliverable. A total of 305 usable responses was obtained. While the overall response rate was about 50% it should be noted that about 75% of those who received the questionnaire completed it.

The follow-up questionnaire was relatively short, focusing on factual data such as college attended, graduate school attended, and major, etc. High school data were obtained from transcripts, nomination forms to the SHP standardized tests, as well as questionnaires filled out at the time of acceptance in SHP.

Results

One of the most striking aspects of the study is the degree to which the respondents were successful at each of the levels of education. The data will be presented in sequence of educational level, first high school, then college and graduate school and finally subsequent publication.

High School

The group selected for SHP is quite talented. The mean IQ in the group is approximately 140. Since GPA data were obtained from different schools, no direct figures can be obtained but the majority of the sample had straight A averages. As a group they

come from relatively advantaged backgrounds. Most of the fathers (73%) and most of the mothers (61%) of the SHP students had attended college. A substantial proportion of the fathers (34%) and the mothers (13%) had attended graduate schools. Approximately 73% of the fathers were employed either in a professional level job or teaching. The majority of the SHP students listed math, science, or engineering as their first choice of college major (94%).

College

All of the students in the sample attended college. As might be expected most of the students attended relatively prestigeous colleges. Columbia, Cornell, City, Harvard, MIT, Princeton, and Rochester were the most frequently chosen schools, accounting for more than half of the students.

In presenting data on majors, three categories of majors were established. In the non-science category both the humanities and the social sciences were included. This was done because of the relatively small number of students in the social sciences at each of the levels of education. The category of biological sciences included medicine. The category labeled physical sciences includes engineering and mathematics.

At college most students did what they said they were going to do in high school. Table 1 presents data on the anticipated major indicated in high school as well as actual major in college. A majority of the students in each of the three categories stayed in the major they announced. It is interesting to note that there was some migration back into science, contrary to the suggestions of Cooley (1963).

Test score data seems to distinguish between those migrating out of science and those remaining in science. Although both math and science tests were given to the SHP students in high school only the math scores distinguished between those who remained in science and those who left science. It is interesting to note that the biological science majors have math scores lower than the physical science majors.

Roe (1965) suggested that her creative scientists manifest their interest in science by spending time working in their own labs. Relating to this proposition, data on the presence of a lab in the home and the winning of science related awards was compared for the various college majors. Table 3 presents the data on both the lab and the awards.

Although the differences in number of awards won by majors in the various fields did not differ there was a significant relationship between choice of major in college and presence of a lab in the home during high school.

Finally, there was a relationship between sex and the choice of major in college. Males are more heavily represented in the physical sciences while females as a group are more heavily represented in the biological sciences. Table 4 presents the relevant data.

Graduate School

A majority of the students in the sample attended graduate school. Over 80% of the initial group attended graduate school, the majority majoring in science.

Again at the graduate school level most of the students majored in the subject they intended to major in when in high school.

Table 5 presents the data. Similarly, data are presented on the graduate school major by various college majors.

In both sets of data a majority of the students follow a consistent path. Consistent with the Cooley data most of the migration is out of science, although there is some migration back into science from the liberal arts majors.

Again at the graduate school level there is a relationship between choice of major and level of ability in mathematics. Physical scientists as a group score higher in math aptitude while in high school than did biological and non-science majors.

At the graduate school level there are significant differences in the various majors in the awards won in high school and the presence of a lab in the home. Table 8 presents the data.

Those who continue their interest in science through graduate school are more likely to have had a lab in the home and to have won awards for their work. Finally, at the graduate school level the preference of females for the biological sciences as opposed to the physical sciences is evident. Table 9 presents the data.

Scientific Publications

The group of students enrolled in SHP is an extraordinarilly talented group. One would expect that they have the potential to make significant contributions to the scientific enterprise. Objective measures of scientific contribution are difficult to obtain. A scientist or engineer may make a significant contribution to out society without ever publishing an article or book. An engineer can design magnificent structures and a physician can save many lives without publishing. Nevertheless, among scientists

publication is one route towards success which can be measured in a relatively objective fashion. Consequently we chose to look at those factors distinguishing those who publish in science from those who do not. It is interesting to note that almost a third of the group in the sample had published at least one scholarly work in the no more than ten years after college graduation.

There seems not to be a relationship between the major a student anticipates when he is in college and publication in science related fields, as is indicated in Table 10.

Table 11 presents data on publications in all fields as related to graduate school major. It should be noted that almost all of the publication was done by those who had attended graduate school. (Of the 126 who indicated publications 121 attended a graduate school.) The relationship between graduate school major and publication is not significant.

Scores on math tests had been shown to distinguish between those who went to college in science or not at persistance in the physical sciences in graduate school. On one of the tests (the STEP math) there was a tendency for those with publications to have scored higher. The data is contained in Table 12.

Table 13 presents data relating to science awards won in high school and the reporting of a lab in the home and publications in science. There is a relationship between both variables and publication. An early depth of interest in science seems to be related to scientific publications.

There seems to be a relationship between sex and publications. Table 14 presents the relevant data.

Although the males in the sample were more likely to produce scientific publications the rate of publications in non-scientific areas was comparable.

Discussion

One of the most striking aspects of the data presented is the degree to which a promise indicated in high school is fulfilled later in life. While the presentation of data in this paper has focused on scientific productivity even those who migrated out of science into other fields have been quite successful. The selection mechanisms of the Science Honors Program seem to have identified a group of students who become quite successful in terms of subsequent academic performance.

In view of the fact that the population studied was highly selective, marked differences between those studied who continue in science and those who drop out were not anticipated. Nevertheless, there was a relationship between scores on math tests and subsequent activity in science that persisted through the level of scientific publications. A talent for mathematics seems to be associated with success in the scientific enterprise, especially in the physical science area.

There are also early indications of the tendency of some individuals to remain in science. Those who say they are going to choose a non-scientific major when in high school are quite likely to do what they say they are going to do. Over half of the sample who went to graduate school majored in an area related to the major they suggested in high school. Similarly, those who displayed an early interest in science by developing a home lab

of their own or by winning scientific awards are more likely to persist in and be successful at science. Contrary to the findings of Cooley (1962) there seemed to be a two-way migration both in and out of science although the migration out was greater than the migration into science. This might be accounted for on the basis of the level of talent in the group under study. Each individual in the population probably had sufficient academic talent to be successful in the scientific enterprise. Even those with relatively low scores on the math tests were substantially above the national averages for college students. Since talent may have been one of the major factors operating in the Cooley study in determining out migration, the differences here might be due to the relative levels of talent in the groups under study.

In an earlier paper (Hansen and Neujahr, 1973) we dealt with some of the male - female differences observed in greater detail. It is sufficient to note that there are differences in the scientific preferences of females and males reflected in the choice of major at each of the subsequent levels of education and in publication rates subsequent to the termination of formal education.

TABLE 1

Actual College Major and Major Anticipated in High School

College Major	Major Anticipated in High School		
Major	Non-Science	Biological Science	Physical Science
Non-Science	8 (61%)	14 (36%)	48 (21%)
Biological Science	2 (15%)	18 (46%)	24 (10%)
Physical Science	3 (23%)	7 (18%)	157 (69%)
	13	39	229

$x^2 = 55.1$, df = 4, p less than .01

TABLE 2

Means and Standard Deviations of Scores on the STEP Math Test and the Pre-Engineering Ability Math Test for Various College Majors

	TEST					
	STEP Math			Pre-Engineering Ability Math		
	Non-Science	Biological Science	Physical Science	Non-Science	Biological Science	Physical Science
Mean	35.7	33.9	38.9	34.7	33.2	36.5
Standard Deviation	6.9	6.3	5.3	4.3	4.2	4.4
Number	35	18	63	25	16	55
	F=6.47, df=2, 113, p less than .01			F=4.13, df=2,93 p less than .05		

TABLE 3

Number of Science Related Awards Won in High School

	College Major		
	Non-Science	Biological Science	Physical Science
Mean	2.2	2.7	3.3
Standard Deviation	1.9	3.0	2.4
Number	71	43	158

$F=5.40$, $df=2,263$, p less than .01

Had a Science Lab in the Home while in High School

	College Major		
	Non-Science	Biological Science	Physical Science
Yes	12 (16%)	13 (30%)	58 (37%)
No	62 (84%)	31 (70%)	100 (63%)

$x^2=10.07$, $df=2$ p less than .01

TABLE 4

Sex and College Major

	College Major		
	Non-Science	Biological Science	Physical Science
Male	58 (73%)	23 (50%)	147 (85%)
Female	21 (27%)	23 (50%)	26 (15%)

(x^2=25.3, df=2, p less than .01)

TABLE 5

Actual Graduate School Major and Major Anticipated in High School

Graduate School Major	Major Anticipated in High School		
	Non-Science	Biological Science	Physical Science
Non-Science	6 (55%)	14 (37%)	61 (31%)
Biological Science	3 (27%)	21 (55%)	34 (17%)
Physical Science	2 (18%)	3 (8%)	104 (52%)

$x^2=38.6$, $df= 4$, p less than .01

TABLE 6

Graduate School Major by College Major

College Major	Graduate School Major		
	Non-Science	Biological Science	Physical Science
Non-Science	65 (71%)	7 (11%)	1 (1%)
Biological Science	6 (7%)	38 (61%)	2 (2%)
Physical Science	20 (22%)	17 (27%)	112 (97%)

$\chi^2 = 256.58$, $df = 4$, p less than .01

TABLE 7

Means and Standard Deviations of Scores on the STEP Math Test and the Pre-Engineering Ability Math Test for Various Graduate School Majors

	TEST					
	STEP Math			Pre-Engineering Ability Math		
	Non-Science	Biological Science	Physical Science	Non-Science	Biological Science	Physical Science
Mean	35.9	35.1	38.7	34.9	33.1	37.1
Standard Deviation	6.1	5.7	6.3	4.1	4.4	4.5
Number	43	22	38	24	19	45
	F=3.25, df=2,100, p less than .05			F=5.96, df=2,85, p less than .01		

TABLE 8

Number of Science Related Awards Won in High School

	Graduate Major		
	Non-Science	Biological Science	Physical Science
Mean Number of Awards	2.5	2.8	3.4
Standard Deviation	2.0	2.8	2.5
Number	83	56	106

F=3.58; df=2,242; p less than .05

Had a Science Lab in the Home while in High School

	Graduate Major		
	Non-Science	Biological Science	Physical Science
Yes	15 (17%)	18 (33%)	36 (34%)
No	71 (83%)	37 (67%)	70 (66%)

x^2=7.24; df=2; p less than .05

TABLE 9

Sex and Graduate School Major

	Graduate Major		
	Non-Science	Biological Science	Physical Science
Male	63 (69%)	37 (61%)	101 (80%)
Female	28 (31%)	24 (34%)	14 (12%)

(x^2=18.5, df=2, p less than .01)

TABLE 10

Publications and Major Anticipated in High School

Publications in Science	Major Anticipated in High School		
	Non-Science	Biological Science	Physical Science
Yes	2 (18%)	10 (26%)	77 (41%)
No	9 (82%)	28 (74%)	111 (59%)

$x^2 = 4.72$, df=2, p greater than .05

TABLE 11

Scientific Publication by Graduate School Major

	Graduate School Major		
	Non-Science	Biological Science	Physical Science
Published	25 (33%)	19 (40%)	82 (44%)
Did not Publish	51 (67%)	28 (60%)	86 (51%)

$x^2=5.59$, df=2, p greater than .05

TABLE 12

Means and Standard Deviations of Scores on the STEP Math Test and the Pre-Engineering Ability Math Test and Publications

	Test			
	STEP Math		Pre-Engineering Ability Math	
	Scientific Publication	No Scientific Publications	Scientific Publications	No Scientific Publications
Mean	39.3	35.4	35.9	34.8
Standard Deviation	5.6	6.3	5.2	3.9
Number	30	69	39	46
	t=3.07, p less than .01		t= 1.09, p greater than .05	

TABLE 13

Number of Science Related Awards Won in High School and Publication

	Science Related Publications	No Science Related Publications
Mean	3.3	2.7
Standard Deviation	2.4	2.2
Number	87	150

t=1.92*

* p less than .05

Had a Science Lab in the Home while in High School and Publication

	Science Related Publications	No Science Related Publications
Yes	32 (37%)	34 (22%)
No	54 (63%)	120 (78%)

x^2=6.4, df=1, p less than .05

TABLE 14

Sex and Publications

Sex	No publication	Scientific Publications	Non-Science Publications
Male	96 (69%)	78 (85%)	19 (68%)
Female	43 (31%)	14 (15%)	9 (32%)

$x^2 = 7.9$, df=2, p less than .01

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